Chemical & Engineering NEWS

Natural gas-based petrochemicals
A Key Chemicals Review Page 18

Controversy still rages on ban
of urea-formaldehyde foam Page 34

A1250-1
3/82

0511179C092 9 W AR60135L 1
CONGRESSIONAL INFO SERV
4520 EAST WEST HWY SUITE 800
BETHESDA MD 20814

BIOTECHNOLOGY

Stakes high, outcome uncertain

Page 10

March 29, 1982
Volume 60, Number 13
CENEAR 60 (13) 1–60
ISSN 0009-2347

Chemical & Engineering NEWS

Cover: Detail from "The Card Players"; Lucas van Leyden (after). Photo courtesy of National Gallery of Art, Samuel H. Kress Collection (Washington, D.C.)

4 Letters

Concentrates
16 Business
33 Government
38 Science/Technology

The Departments
48 ACS News
60 Newscripts

News of the Week

- ***OSHA's proposed rules*** *for labeling hazardous substances in the workplace require chemical makers to evaluate their products to determine if they are health risks.* ***Page 6***
- ***GAF has had a merger offer*** *from a major corporation and bids from two other firms for its building materials business, which accounts for 55% of sales.* ***Page 7***
- ***New technology will reduce operating costs*** *of Union Carbide's Unipol linear low-density polyethylene process, increase capacity at Taft and Seadrift.* ***Page 7***
- ***American Hoechst's profits*** *in 1981 attributed to improvement in polyester fibers and pharmaceuticals sales; 1982 earnings predicted to drop.* ***Page 8***
- ***State Department accuses*** *the Soviet Union and its allies of using chemical warfare agents in Southeast Asia in report to Congress and the United Nations.* ***Page 8***

News Focus

- ***The biotechnology industry*** *is having its ups and downs financially; venture capital investors who have a stake in the business may welcome the predicted shakeout.* ***Page 10***

Business

- ***Makers of gas-based petrochemicals*** *ammonia, urea, methanol, and formaldehyde hope to at least match 1981 output even though imports cut markets.* ***Page 18***
- ***Synthesis gas-based chemicals*** *are not economical enough to attract investment without government subsidies.* ***Page 28***

Government

- ***CPSC's controversial ban*** *on use of urea-formaldehyde foam insulation affects real estate as well as industry.* ***Page 34***

Technology

- ***Conduit system*** *to transmit large amounts of electrical power underground uses sulfur hexafluoride gas as insulator.* ***Page 39***

Science

- ***Stanford struggles*** *with conflict of interest dilemma; school of medicine ad hoc committee makes recommendations.* ***Page 40***
- ***Interest stirred in electromolecular propulsion*** *as Haber Inc. looks for possible practical uses.* ***Page 40***

Science Policy

- ***Public concern arises as new force*** *in science policy; reports contend disenchantment must be reckoned with.* ***Page 43***

Books

- ***Nuclear energy*** *viewed by British science writer Ronald Clark in his latest book, "The Greatest Power on Earth."* ***Page 45***

HAZARDOUS CHEMICALS LABELING RULE PROPOSED

The Occupational Safety & Health Administration finally has issued a proposal calling for the labeling of hazardous substances present in the workplace. The announcement of the new proposal came on the eve of House hearings designed to find out why it had taken more than a year for the proposal, which was first issued and then withdrawn last January, to be reworked and reissued. Reaction from both labor and industry was swift, but divergent.

The proposed standard is very much performance-oriented and differs considerably from the approach taken by the Carter Administration (C&EN, Jan. 26, 1981, page 11). It requires chemical manufacturers to assess the hazards of chemicals that they produce, and all employers having facilities in the manufacturing sector, SIC Codes 20-39, to provide information to their employees about these hazards by means of hazard communication programs, including labels, placards, material safety data sheets, information and training, and access to written records.

The main burden of complying with the standard and most of the costs would fall on chemical manufacturers, who are defined as "establishments where chemicals are produced for use or distribution." Under the proposal, each manufacturer is required to evaluate the chemicals it produces to determine whether or not they are hazardous. Manufacturers may use whatever procedures they choose, so long as they can demonstrate that the scientifically well-established hazards of the chemicals have been ascertained adequately.

An appendix to the proposal published in the March 19 *Federal Register* contains a list of available references that employers may decide to use to do the hazard determination. However, OSHA cautions that although one source may be adequate for physical hazards, such as flammability, a more thorough search may be required to determine which chemicals present health hazards.

Once employers determine which chemicals are hazardous, they are required to label every container in the workplace with the identity of the hazardous chemical contained therein and with hazard warnings. Containers are defined as "any bag, box, can, cylinder, drum, storage tank, reaction vessel, or the like that contains a hazardous chemical. Pipes or piping systems are not considered to be containers." The warning may take whatever effective form employers wish from numerical ratings to pictographs. OSHA believes that most existing labeling systems can be used to satisfy the requirements.

In addition, employers must prepare material safety data sheets for each of the chemicals and make them available for worker inspection. Information on the data sheets is to include: chemical names, common names, and Chemical Abstracts Service numbers for ingredients present in specified concentrations; physical hazards and/or known chronic and acute health effects; routes of entry; precautions for safe handling and use; effective work practices and personal protective devices; emergency and first-aid procedures; and date of preparation.

The data sheet must accompany first shipments of any hazardous chemical by the manufacturers to their downstream customers, who then can rely on the data sheets to determine what hazards they must inform their own employees about. Containers leaving the manufacturers must be labeled with identity and hazard warnings, as well as the name, address, and telephone number of the manufacturer.

Other provisions of the proposed standard include: labels and warnings on mixtures comprised of at least 1% of a hazardous chemical; exemption for chemicals that are being developed and used in research labs (although chemicals being used in other labs, such as quality control labs, would be covered); and protection of trade secrets—a provision much sought by the chemical industry. Generic names can be used to mask ingredients that are trade secrets unless the chemical is a carcinogen, mutagen, or teratogen, or is a cause of significant damage to human organisms or body systems. In any case disclosure of the precise chemical substance must be made to a physician treating a patient

Chemical manufacturers would bear most of the initial costs of the labeling standard

(SIC)	Expected initial cost ($ millions)	Cost as % of payroll	Cost as % of value-added	Average cost per employee
(20) Food and kindred products	$ 13.70	0.07%	0.03%	$ 11.90
(21) Tobacco manufacturers	0.67	0.10	0.02	13.63
(22) Textile mill products	7.43	0.10	0.05	11.07
(23) Apparel and other textile products	12.21	0.14	0.07	11.02
(24) Lumber and wood products	7.71	0.12	0.06	14.93
(25) Furniture and fixtures	4.58	0.13	0.06	12.80
(26) Paper and allied products	5.83	0.07	0.03	12.16
(27) Printing and publishing	15.04	0.12	0.05	17.37
(28) Chemicals and allied products	415.01	3.36	0.81	651.35
(29) Petroleum and coal products	1.25	0.05	0.01	12.54
(30) Rubber and plastic products	6.90	0.10	0.04	12.47
(31) Leather and leather products	2.33	0.13	0.07	12.49
(32) Stone, clay, and glass products	5.90	0.08	0.03	13.36
(33) Primary metal industries	9.51	0.06	0.03	10.59
(34) Fabricated metal products	14.76	0.08	0.04	12.62
(35) Machinery, except electrical	19.08	0.07	0.03	13.01
(36) Electrical equipment and supplies	14.91	0.07	0.04	11.10
(37) Transportation equipment	14.14	0.05	0.02	10.67
(38) Instruments and related products	4.98	0.07	0.03	12.98
(39) Miscellaneous manufacturing products	4.95	0.12	0.06	15.15

Source: Occupational Safety & Health Administration

whose health problems may be the result of occupational exposure.

Patrick Joyce of the Chemical Manufacturers Association says the present proposal is a "vast improvement" over the one offered by the Carter Administration, even though it is a "very expensive one" as far as the chemical industry is concerned. CMA still sees a few problems in the standard but feels that they are minor compared to the ones posed by the earlier proposal. CMA's general feeling is one of relief that a federal standard has been issued in light of moves by a number of states and cities to write their own labeling standards. And Joyce says the standard is evidence that this Administration will regulate in the area of health and safety, which many had contended it would not.

One of those is Sheldon Samuels of the AFL-CIO's Industrial Union Department, who sees the new proposal as further evidence that "this Administration will not respond in a morally responsible manner." He says IUD's basic objection to the proposal is that it doesn't meet the objectives spelled out in the Occupational Safety & Health Act that workers know the names of the chemicals they are exposed to. "We are not interested in management's opinion of what is and what is not hazardous," he says. "What we need are the names of the chemicals. With those, we can go to our own computers and access a wide range of sources and find out what happens when workers are exposed to different chemicals at different levels."

Samuels says that though he is sure others in the labor movement will challenge the proposal, "IUD will not waste its resources on this issue until the political climate changes to the point where a responsible standard has a chance of being promulgated." □

GAF may merge with chemical company

GAF may be the object of a takeover. Or it may sell off its important building materials business.

The New York City-headquartered company says that it has received inquiries from a "major corporation" asking whether GAF would be willing to be merged into that company. The major corporation has not been identified. GAF adds that it has received advances from two other companies—also unidentified—asking whether it might be willing to sell its building materials business.

The company has replied in the affirmative to all of these inquiries. So at this point it is anyone's guess what will happen.

Over the past year and a half GAF has sold off about half of its assets, leaving it essentially a building materials and chemicals company. In 1981, chemicals accounted for about 45% of GAF's sales of $673 million with building materials supplying the other 55%. More important, chemicals last year showed a pretax profit of $56.6 million, whereas building materials, battered by the recession in construction, had an operating loss of more than $38.5 million. This included a provision in the fourth quarter of $15.1 million for the possible shutdown of certain plants. Thus pretax loss from operations for building materials last year was about $23.5 million.

Although it is not known just what companies may be interested in GAF, speculation is centering on a chemical company for the merger. It would have to be a company that is not already in the roofing products business.

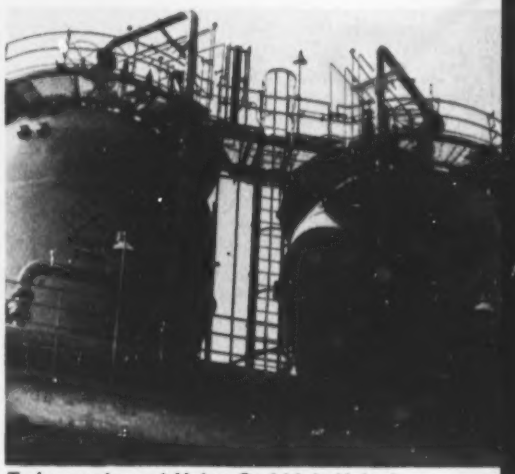
If the building materials business were sold off, it would leave a new medium-size chemical company with annual sales of between $300 million and $400 million. This is a far cry from GAF's size before it started its reorganization program. In 1979, the company had net sales of more than $1.2 billion. □

Carbide lifts efficiency of linear LDPE process

Union Carbide says it has new technology that will reduce operating costs for its Unipol linear low-density polyethylene. The technology also will increase the capacity of its reactors 35% at Seadrift, Tex., and Taft, La.

The Taft unit was originally designed to produce 600 million per year of linear low-density polyethylene. The new process will boost its capacity to more than 800 million lb annually. Seadrift's capacity will be increased from 300 million lb currently to more than 400 million lb per year.

At a press conference in New York City last week, Elio E. Tarika, executive vice president of Union Carbide, stated that the technology advances also will be made available to Unipol licensees. He says the new technology is expected to give the licensees operating cost and capacity improvements in their existing Unipol plants and those under construction similar to those achieved at Taft and Seadrift.



Twin reactors at Union Carbide's Unipol polyethylene plant in Seadrift, Tex.

With the new technology, Tarika says that "the investment needed to build a grass-roots Unipol process plant now can be less than one third of that customarily needed for plants using competing processes. For example, we estimate that a world-scale plant can be built today on the U.S. Gulf Coast for less than 6 cents per annual lb, despite the ravages of inflation—less than what it cost to build a state-of-the-art polyethylene plant 15 years ago."

Tarika also says that Unipol process reactors can be substituted for existing hardware in high-pressure plants for as little as 3 cents per annual lb. This, he points out, offers major advantages over converting the present reactors to production of linear low-density polyethylene.

Thus, Carbide seems to be taking aim at Dow Chemical's plan to license a process to convert high-pressure plants to linear low-density polyethylene using existing hardware (C&EN, Sept. 21, 1981, page 18).

The process also cuts energy costs for making linear low-density polyethylene, Carbide says. According to Tarika, Unipol process energy requirements, initially one fourth those of conventional high-pressure processes, have been reduced further to just one sixth the energy needed with most competing processes and as lit-

Biotechnology: a high-stakes industry in flux

Imminent shakeout in this fledgling business forecast by many observers actually might be welcomed by some groups, particularly venture capital investors

Jeffrey L. Fox
C&EN, Washington

Practically every sachem and soothsayer in the business has been quoted recently—whether in the financial sections, the Sunday supplements, or elsewhere—predicting the imminence of a shakeout in the fledgling biotechnology industry.

Several recent events—particularly a cutback and reorganization at Bethesda Research Laboratories, a biotechnology company based in Gaithersburg, Md.—are eliciting much seemingly sagacious head shaking and tut tutting. Such displays of wisdom usually are reserved for critics who expound on their favorite baseball teams when they fall into their annual August slump.

Without doubt a certain shakeout is under way in biotechnology. It began almost before the ink dried on the first set of research contracts, partnership agreements, and corporate papers. However, if the signs of a shakeout are increasingly visible, merely noticing them says very little about the makeup of this industry and what's likely to happen to it in the months ahead. Just as faded allegiance in sports fans during the late summer tells little about the glories and the difficulties of playing winning baseball, so can the current stumblings in biotechnology belie an important but complicated drama behind the scenes.

Some of that drama might have been planned by some of the participants from the start. Whether planned or haphazard, it could result in a significant rearrangement of power within the industry.

The biotechnology boom has been peculiar and by no means simple from its start. That boom is only about two years old, and thus some of the entities it has created are not likely to die yet of old age. The forces, at least some of the forces, that were instrumental in first building interest and momentum in biotechnology do not necessarily want or expect the whole thing to go immediately into seizures and collapse. Too much is happening and too much money has been invested for that result to be likely, unless the whole basis for the boom was false to start. A broad collapse isn't even considered very desirable because, even if some people might profit thereby, it's too soon for many people to profit that way.

A great deal of money is at stake in biotechnology. By low estimates at least $500 million has gone into publicly and privately held new corporations. Some financial analysts say that those investments actually could be several times higher—and that is just looking at efforts under way at the relatively new research-oriented firms and not counting how much has been invested in new programs at established chemical, pharmaceutical, and allied companies. A full-scale shakeout would mean that a major portion of that money has been squandered.

Money is squandered all the time, of course. And entrepreneurial biologists and their comrades haven't necessarily avoided making their quota of wasteful mistakes. Certainly, the rapid and proliferative growth of new companies lends itself to some unwise planning (or lack of planning), hackneyed research, and other generally wasteful business and scientific practices. It also may have lent itself to some awkward and potentially damaging misunderstandings among the various parties—the scientists, managers, investors, and anyone else involved—who have contrived to set up so many new companies having such similar overall goals.

Nonetheless, in the aggregate, this is not a group of stupid people. New to the game, certainly. But not stupid.

The participants are all playing a game, and it complicates matters that not everyone plays by the same rules. The style of play, the stakes, the varieties of short- and long-term strategies, the varied commitments of the investors and the other players—these and many other factors make an analysis of the purported biotechnology shakeout an inexact enterprise.

One factor not to be underestimated in evaluating the life expectancies of young biotechnology corporations is the private investors who have underwritten this new industry. Their patience, commitment, and wisdom must be reckoned with before more nebulous factors, such as the "mood of the market," are considered.

More than any group involved, the private investors—and particularly the venture capitalists—are the principal gamblers in the biotechnology game. If their interest at times almost seems more in savoring risks rather than in realizing monetary gains, that appearance may be deceptive. Venture capital investors can lure money away from other investors for their own use and placements for reasons that are practical as well as rakish. Venture capitalists have earned a reputation for outracing the rate of inflation. More important, they routinely outperform more timid investors. That's why more conservative money managers, such as the people who run insurance companies or who oversee pension funds, are willing to channel a small percentage of their long-term holdings into these high-risk outlets.

To deserve their reputations, venture capitalists need to stay on the winning side fairly often. Ideally, their individual investments will bring a 10-fold return or, even better, the jackpot returns that can soar another order of magnitude higher. Realistically, some investments in a particular venture capital firm's portfolio are losers. Thus, the overall return can be much more modest, possibly in the range of 20 to 30%, according to an industry source. Because that return can vary upward quite a bit, because tax advantages and a widespread gambling instinct

Documented biotechnology investments total about $500 million

Biotechnology company	Investor(s)	$ Millions
Adria Laboratories	Hercules	$1.0[a]
	Montedison	1.0[a]
Advanced Genetic Sciences	Rohm & Haas	12.0
Applied Molecular Genetics	Abbott Laboratories	5.0
	Tosco	3.5
Bethesda Research Laboratories	Private	8.0
BioCell Technology Corp.	Public offering	2.6
Biogen	Schering-Plough	8.0
	Inco	12.0
	Monsanto	20.0
	Grand Metropolitan Ltd.	10.0
Bio-Response	Public offering	5.0
Biotech Research Laboratories	Ethyl Corp.	1.0
Calgene	Allied Corp.	1.0[a]
Cetus	National Distillers	5.0
	Standard Oil of California	13.0
	Standard Oil (Ind.)	10.0
	Public offering	120.0
Collaborative Genetics	Dow Chemical	5.0
Collaborative Research	Dow Chemical	5.0
	Public offering	13.0
Collagen Corp.	Monsanto	1.0[a]
Cytox	Public offering	3.0
DNA Plant Technology Corp.	Campbell Soup Co.	10.0
DNAX Corp.	Private	1.0[a]
	Alza Corp.	1.0[a]
Engenics	Bendix, General Foods, Koppers, Mead, Noranda Mines, Elf Aquitaine	10.0
Enzo Biochem	Public offering	4.0
Genentech	Lubrizol	25.0
	Japanese group	4.5
	Fluor Corp.	9.0
	Public offering	35.0
Genetic Engineering	Public offering	4.0
Genetic Systems Corp.	Private	1.0
	Public offering	6.0
Genetics Institute	Private	5.0
Genex	Koppers	25.0
	Monsanto, Emerson Electric[b]	10.0[a]
Hybritech	Kleiner, Perkins, Caufield & Byers; Sutter Hill Ventures; Asset Management Co.	13.0
Interferon Sciences	Public offering	10.0
Molecular Genetics	Private	1.0
	American Cyanamid	5.0
Repligen	Private	5.0
Salk Institute Biotechnology Corp.	Phillips Petroleum	10.0
Southern Medical & Pharmaceutical Corp.	Public offering	23.0
	Key Energy Enterprises	7.3
Viragen	Public offering	9.0
Viratek	Public offering	4.0
TOTAL[c]		$502.9

a Industry estimate. b Via Innoven. c As of Oct. 4, 1981. Source: Sittig & Noyes

encourage participation, and because no major venture capital group so far has blown everything and failed utterly, the 50 to 100 such groups in the U.S. have received something like $1 billion annually for investing during the past few years. Only a fraction of that sum goes into biotechnology.

So what is the venture capital strategy in biotechnology?

It varies considerably, and right now may be falling into different and possibly opposite slots that could reflect the different positions and different time frames that certain venture capitalists find themselves in regarding their biotechnology placements.

Thus, for example, a venture capital group that put money into biotechnology companies several years ago and sees those companies beginning to succeed might very well begin to welcome a shakeout, expecting still newer companies—the eventual competition—to be the shakiest. However, other venture capital groups that would like to place new investments also can benefit from word of a shakeout. Fear of scarce money can force an entrepreneur to give up more equity or otherwise bargain from weakness while seeking venture capital funds.

Regardless of where a venture capital group decides to invest, it tends to evaluate each potential investment according to fairly well-accepted precepts. Though acting similarly to anyone applying principles of sound business management, venture capitalists tend to argue that they apply these rules more rigorously and possibly more shrewdly than do other investors. Moreover, venture capital placements usually come early in a company's development, thereby setting a limit on the potential loss but virtually no limit on the potential gain for the investor, should the company take off.

The managers of venture capital funds pride themselves on their ability to understand the needs and potential pitfalls of a young company. "The danger is that most young companies stumble," says Thomas Sager of Rothschild Inc., formerly New Court Securities, in New York City. Sager is part of a team administering a $46 million fund intended mainly for biotechnology. "We can bring—in addition to money—perspective and knowledge and expertise [regarding] the startup traumas faced by all young companies," he adds. "We don't know every mistake, but we've seen lots of them."

From the outset, a venture capital investor takes a long-range, or at least a medium-range, stance. "We're going in for five to seven years," Sager says. Efforts by the venture group during that period can dwarf what takes place during the initial investigation of a business plan. Others who are involved in venture capital investing say that the time frame for realizing profits from genetics research could be even longer than seven years. The point is that an astute venture capital firm knows there is a need for patience from the beginning.

"A company goes through several phases," notes Yung Wong, East Coast managing director of Menlo Ventures, a California-based partnership that so far has come close but has not closed any biotechnology deals. "We don't want to overcapitalize a company at an early stage. If we put in money, we can expect to put in more, either to help the company

expand or help it through a bad time," he says.

"Most deals are in a spending mode," Sager says, referring to new biotechnology companies. Thus products and profits simply aren't expected for another few years. "We will finance people to the checkpoints we set up—not necessarily a product, maybe just a lab prototype." And thus a pattern is widely recognized whereby new ventures tend to grow in stages—sometimes in quantum leaps—depending on how well they appear to be doing. By the same logic, however, the companies usually and deliberately are kept from ever having a surfeit of cash during the early stages, lest they grow overconfident and forget how to spend that money wisely.

Deviations from this rule can and do lead companies into trouble. Bethesda Research Laboratories' (BRL) recent experiences illustrate the difficulties of adhering to this formula and what can happen when it's misused.

BRL was founded in the mid-1970s by Stephen C. Turner and a research partner. The company's first line of products included the "restriction" enzymes that are used widely for doing recombinant DNA experiments. Along with growth in biotechnology generally, BRL grew rapidly during the past few years, flourishing in part because of brisk enzyme sales. To underwrite this rapid growth, BRL received several private placements, including one from a small venture capital firm in Baltimore and, more recently, a somewhat larger private placement, according to BRL spokeswoman Michelle Hartz.

The company posted record sales revenues of more than $10 million in 1981. But, Hartz says, "We encountered cash flow problems in the past few months because of fluctuations in the business environment." Hence, according to Hartz, BRL fired about 150 employees, leaving some 300 still with the company, about 55 of them Ph.D. holders. The company also has reorganized, paring down programs in the medical diagnostics area and in genetics research. Also, the company secured $1 million in "bridge" financing and is obtaining an additional $5.5 million from private sources, mainly in Europe.

Perhaps more important, BRL's board of directors has been changed, making it "outsider dominated." Two new board members, William Janeway, director of corporate finance at F. Eberstadt & Co., the New York City investment firm that helped see BRL through its current difficulties, and Fred Adler of the New York City law firm Reavis & McGrath have been added. Adler was named chairman of the executive committee of the board, which will focus on increasing the cash flow and return on investment at BRL.

An analyst close to BRL says, "This is the finest entrepreneurial firm, bar none, in the U.S." Referring to the current mishaps, he says, "This is not unusual, just the first time in biotechnology." In saying that, he echoes what other investment analysts and venture capital strategists say about this and other new firms: They are likely to make mistakes.

However, a few oddities make the BRL case particularly noteworthy. First, the firing of scientists and other employees in a company that has been growing because of a lively sales base rattles the nerves of many observers of the biotechnology scene, particularly the people who've thrown in their lot with the industry. And second, the transfer of power, no matter how limited, from the entrepreneur director to outsiders signals a possibly significant change that might augur a general trend within the industry.

It's difficult to learn just how things got snarled at BRL. The company wanted, among other things, to go public, but public offerings aren't doing well right now. Other rumors abound regarding BRL's intentions, including one that the company was looking to be acquired. But there's little doubt that the company had been expanding at a near-reckless rate, doubling its staff and sales nearly every year. Spurred by such success, company planners broadened their horizons in leaps and bounds, and just this year BRL is introducing fairly complex instruments, including a semiautomatic nucleotide-linking machine (a "gene synthesizer"). Making and marketing such products requires plenty of capital and means competing with other experienced outfits that offer similar equipment.

The question here is not whether BRL belongs in this different, possibly lucrative, and certainly competitive marketplace. The question, rather, is who among the many experienced planners—the very people who expect young companies to need infusions of fresh cash and also expect such companies to stumble—failed to foresee what was bound to happen. An analyst familiar with BRL's current trouble says now, "Starting last summer, this operating business was transferred back into a venture mode without anyone there to control it." Turner, who is BRL's largest shareholder, "ran the company like a proprietorship," the analyst adds. "Eberstadt is partly to blame, Turner's partly to blame. It just happened."

C&EN staff photos

Wong: firm goes through several phases

"The reason for restructuring is to make it, solo," asserts BRL's Hartz. Turner has an "unfaltering commitment" to the company, she says. And, everyone agrees, it was Turner and the rest of BRL's management team, not the outsiders, who decided how to restructure and whom to let go.

Such decisions can exert secondary effects. In a small technology-based company, the loyalty and talents of the employees are important assets.

Niven: good person can save a bad idea

Weinberger: hot market at the time

Dismissing a third of them—because of mismanagement, not because of any fault of the work staff—isn't likely to raise the loyalty among those who remain. This could put Turner in an awkward predicament, especially as he seeks advice and counsel in the time ahead. He very well could be forced to look increasingly outward instead of inward to his own staff members.

BRL's experiences are not unique. For example, some restructuring recently occurred at International Plant Research Institute (IPRI), a company devoted to agricultural research and located in San Carlos, Calif. None of it was "earth shattering," according to an IPRI spokeswoman, who adds: "It's not uncommon to have changes in management all the time in a company growing so fast."

Misrock: use of R&D partnerships

"We're geared to stay independent, to build a large base of proprietary technology to make progress," IPRI president Martin A. Apple told a visitor last fall. Nonetheless, certain industry observers contend that his own independence has been curtailed somewhat. IPRI has added an acting chief executive officer, Rudolph Hurwich, to take over some of Apple's former duties. Such changes can be overemphasized and overinterpreted, of course. The point is that control at the corporate level can be fluid, especially during expansionary periods.

Regardless of these portents and despite the current recession, this still is an expansionary period for biotechnology in some ways. New deals still are being made. A generation of "fission" companies is coming to light—that is, companies that bud off from barely established entities, including IPRI and other companies, such as Genentech, which is based in South San Francisco. Several people who recently left IPRI are trying to set up their own company on the West Coast but are reluctant to discuss progress.

At least two groups have budded off from Genentech. One, called Armos, was set up "down the street" less than a year ago by former upper management people, Brian T. Sheehan and Sharon Carlock. Roberto Crea is among the founders of another company, Creative Biomolecules, also in the same area. Crea, an organic chemist who specializes in synthesizing genes, says that achieving a financial deal that he and his partners consider suitable has been difficult. However, he says, "There is no problem about money." The problem has more to do with how to structure a deal that's favorable and will allow for growth. "It's a pain in the neck to start your own organization," Crea admits, adding: "I have the luck to have a second chance, to try to build without making mistakes."

According to some venture capitalists, the recession tends to improve their position and, probably, to encourage company startups. "We're a very different subindustry," Wong of Menlo Ventures explains. "The recession hasn't affected the money coming to us. And it helps when people looking for money can't find it from traditional sources and so come to us."

Thus certain expansionary ingredients, including money, management groups, and willing scientists, are still available for new startups and for sustained activities. The biotechnology shakeout, viewed in that light, won't come about as a simple, general crash.

To be sure, new deals are being scrutinized more critically than before, or so it seems. And emphasis is shifting away from talk of research for its own sake, and more to talk of markets and other hard-nosed business realities.

Yet, for all such talk, evaluating the many biotechnology companies is not so easy, and that may be an important reason why so many separate entities have been blessed with startup money. The gossip from within some of the biotechnology companies, including ones that generally are regarded as well situated, often hints that there is a good deal of chaos, indirection, and befuddlement inside. But if there is chaos and waste, so is there much excitement and progress stemming from intense and directed research efforts.

"It's too early to divide the smart from the not so smart," says R. N. Dryden Jr., president of Agrigenetics, who runs a New York office for this Denver-based seed and agricultural research company. His conclusion sums up what a lot of people realize about the biotechnology industry. Surely it has its share of fools and charlatans, but their talents and weaknesses are not quickly or easily put to rigorous test.

A major reason is that mismatched and misdirected expectations were created at the inception of this industry. That mismatch arises from the overoptimistic use of the word "technology" in reference to virtually basic research in genetics and other similar disciplines as applied to microbes, plants, and animals. Biotechnology is a partial misnomer, depending on who uses the word and in what sense it's applied. Time is helping to cure this abuse of language (freely indulged in here for the sake of convenience). The question is whether investors and scientists can reconcile their different expectations before the scientists run out of the money that the investors have furnished.

Given the vagaries of research and the peculiar unpredictability of success in it, biotechnology is apt to need money, money, and more money before it comes into full bloom. Here again, the venture capital approach does best in setting up many entities to hedge the bets. The system works like a miniature National Science Foundation, except the aim is profit

instead of discovery for its own sake.

The venture capital investor, however, does not possess the same expertise as NSF in picking research to back. "We are really investing in the people," says Wong of Menlo Ventures. He adds: "We basically invest in management, and we're betting on a guy with a proven track record. The problem with a new area is that the track record, in a sense, is not there."

"Research is crucial, but so is the ability to raise money," declares James G. Niven of Pioneer Ventures, a New York-based group that has helped to underwrite Agrigenetics. Agrigenetics has a "strong management team," he says, but admits that he is "not qualified" to judge research managers. But that is simply another aspect of the mismatch problem already mentioned: Investors who may be smart are better attuned to judging managers than scientists and other technical personnel. But as Niven points out, "A good person can save a bad idea, but a bad person can wreck a good company."

Setting aside the issue of good management—an essential problem for running any business, and one for which there are more criteria than there are businesses, investors, or people—survival of biotechnology firms becomes very much a matter of securing funds.

There are several ways to tackle this problem. Several companies—including Genentech, Bio Logicals (Toronto), Cetus (Berkeley, Calif.), and Collaborative Research (Waltham, Mass.)—have made public stock offerings. Of these companies, Cetus reaped the greatest benefits by banking about $110 million last year in its initial offering. But that experience was "an anomaly to a certain extent," says Thomas R. Weinberger of L. F. Rothschild, Unterberg, Towbin, one of the underwriters for the Cetus deal. At the time it was a "hot market" and everything more or less "came together." Since then, the value of the Cetus stock has gone down, but the firm is enjoying use of a hefty bankroll. The more recent public offering of Collaborative Research fared less well, and the initial value at which it sold its stock netted considerably less capital.

A few companies still may be fortunate to develop contract agreements with established corporate partners as a means of funding R&D efforts. But many large corporations are busy developing their own programs and have lost interest in underwriting their small competitors. Also, for small companies in which larger partners maintain possible interests, the partners are more than likely to drive harder bargains and to offer less attractive conditions than before.

Nevertheless, entirely different and sometimes highly imaginative financing schemes still are being devised. Recently Agrigenetics put together about $55 million in "limited R&D partnerships" to help fund its long-term research programs. That money, all from private placements, is more than Genentech raised in its public offering one year ago in a deal that triggered much public fantasizing and some degree of frenzy.

The Agrigenetics scheme was cooked up with the help of S. Leslie Misrock, a partner in the New York law firm of Pennie & Edmonds. Its basis is in sections of the tax code that allow individuals in high tax brackets to benefit from investing in R&D by writing off that money as expenses. And, instead of gaining a straight equity position in the entities that receive that money, the individuals, who become limited partners, are entitled to receive royalty payments after some period. Those payments are taxed as capital gains instead of ordinary income, another benefit to the limited partners—provided of course that any royalties are forthcoming. Moreover, a limited partner's intimate dealings with the R&D beneficiary also might put that partner in a favorable position to acquire equity in the company, should some opportunity arise.

Misrock envisions this and similar schemes as a way of funneling needed money into small, innovative companies. "The real innovation comes out of the hothouse atmosphere at universities and small companies, but somehow is stifled at large companies," he says. However, "most small companies are undercapitalized and haven't a clue of how to get to market with a piece of R&D. They look at research, forgetting the real cost is in development.

"I foresee the use of R&D partnerships along the lines I've sketched," Misrock continues, calling them a valuable means to support "a significant amount of research at universities and small companies." He also considers it possible that venture capital funding and "tax advantaged" R&D partnerships can be fused to carry companies through their most difficult, needy years. "I'd rather see money spent for research," he says. "If it's going to be spent, let's see it where it will do good for the nation."

Meanwhile, that channeling of money and its application to the current and near-future needs of Agrigenetics certainly will do good for the company. It ought to provide an ample cash cushion to pay for a great deal of research, both inside the company and outside—for instance, in university labs. Also, this influx of cash represents the successful cultivation of "still another segment of the investment community," Dryden of Agrigenetics points out. The individuals who make up this segment are pretty well insulated from the cold drafts of the current economy. Thus, says Dryden, "R&D partnerships can maybe get people investing even deeper into the recession."

Agrigenetics has put into action yet another ploy for success and survival, a ploy that is intended eventually to complement its long-range research emphasis. The company is aggressively acquiring seed companies—a pastime that, like basic and applied research, requires plenty of capital. "The short-term crunch for Agrigenetics will be to acquire several more companies," says Pioneer Ventures' Niven, who also sits on the board of directors for Agrigenetics. The trick in acquiring those companies is in doing so without absolute reliance on borrowing money at its current, expensively high, interest rates. For now the important goal, he argues, is to obtain a certain size. "Then, you'll make money. If you worry over money as the prime object, you can lose sight of what you're doing. Let's get there first."

Currently, "acquisitions and research are being kept at arm's length," he continues. But eventually, the two will entwine. The seed companies can put Agrigenetics into many different marketplaces. And the fruits of its research—or rather, the seeds of those fruits—then can be marketed directly.

These few examples give some idea of the transformations that are taking place, or very likely will take place, in companies dedicated to the use of genetic engineering for commercial ends. Sooner or later, these companies must reckon with the realities that their investors will impose and probably will find themselves locking into a particular course of action. Though the companies are apt to find that the available resources won't prove limitless, neither have they yet been exhausted.

People who are watching this industry during its infancy ought to be

Various services offer information about biotechnology companies

The proliferation of corporate activities on the biotechnology front makes it all but impossible for any casual observer to keep pace with the many developments. Fortunately, several guides and directories have been prepared to meet this need. These guides vary in breadth, intent, quality, and expense. A partial survey—C&EN's guide to the guides—provides some idea of what's available.

• "Applied Genetics: A Booming Industry," by Avin Brownlee and Anna W. Crull is published by Business Communications Co., P.O. Box 2070C, 9 Viaduct Rd., Stamford, Conn. 06906, and costs $1250. This report is mainly a market and technology analysis, full of charts and tables estimating possible products that will be affected by genetic engineering, noting statutes and regulations that might be affected, and providing some rundown of major patents and a computer-conducted survey of part of the relevant literature up to and including 1981. The report also includes a partial listing of companies involved in genetic engineering projects as well as a list of some of the joint projects between major established corporate entities and newer, smaller firms.

• "Biotechnology Europe," is published by Imsworld, York House, 37 Queen Sq., London, WC1N 3BL England, and costs $400. A report on biotechnology in Japan also is available for $300, as is a report on the industry in the U.S. for $500. The first report covers 14 countries in Europe and includes a section on European Economic Community activities. It includes a directory of companies.

• "The Commercial Exploitation of Biotechnical Processes in Western Europe Over the Next Twenty Years" is published by Information Research Ltd., 40/42 Oxford St., London W1N 9FJ England, and costs about $400 (195 British pounds). Besides providing a reasonably comprehensive survey of the market and product potential for biotechnology, this report offers listings of European companies and their involvements in such work. It estimates that the Western European market could grow to more than $16 billion by the year 2000, adding, however, that it's "unrealistic" to consider Europe in isolation.

• "The Genetic Engineering Industry Directory" is published by International Resource Development Inc., 30 High St., Norwalk, Conn. 06851, and costs $650. This report provides a company-by-company listing that tells where the headquarters of each company is located, who some of the major officers are, and what some of the companies' main goals, strategies, and projects are. IRD also offers several other reports and market analyses of genetic engineering enterprises.

• "Genetic Engineering & Biotechnology Firms" was prepared and published by Marshall Sittig and Robert Noyes, 84 Main St., Kingston, N.J. 08528, and costs $100. A brief survey of the scientific underpinnings of genetic technology as well as a look at potential applications is followed by a succinct listing of many of the companies (mostly those in the U.S.) engaged in such activity, which includes the location of company headquarters and some of the investment liaisons among companies. However, it does not provide names of company officers. A second, expanded version is being prepared.

• "Genetic Engineering: Business Directory" was published by Strategies Unlimited, 201 San Antonio Circle, Suite 205, Mountain View, Calif. 94040, and costs $950. This report is presented as a company-by-company listing providing a fairly detailed account of major aims of many companies in the biotechnology realm and lists members of the board of directors and board of scientific advisers when that information is available. It also gives names of major investors and the size of their investments when available.

• "An Assessment of the Global Potential of Genetic Engineering in the Agribusiness Sector" was published jointly by Policy Research Corp. and the Chicago Group, 738 North Wells St. and 744 North Wells St., respectively, Chicago, Ill. 60610, and costs $1250. This survey is directed toward agriculture but also wanders through and over some of the other subjects covered in other reports. It includes some lists of academic scientists who have done research in areas related to genetic engineering in agriculture, but is not particularly selective in this presentation.

• Several other listings and also several newsletters covering the moment-to-moment developments in this field are available at varied costs and varying credibility. They include "Genetic Engineering News," published by Mary Ann Liebert in New York City, a group that is rapidly proliferating newsletters; "Biotechnology Newswatch," published by McGraw-Hill; "Genetic Engineering Letter," published by Gershon W. Fishbein in Washington, D.C.; "Biotechnology Patent Digest," edited by Oskar R. Zaborsky in Great Falls, Va.; "BioEngineering News," published and edited by Deborah J. and Thomas G. Musiewicz in San Francisco; and "Telegen," a broad-based scan of the biotechnology literature eventually to be supplemented by a computer-assisted search service, published by Environmental Information Center in New York City.

prudent in making predictions. What may look like telltale evidence, either of imminent failure or solid success, can be misleading—out-and-out false, or at least subject to more than one interpretation. Companies like BRL may be made to play a game of brinkmanship more because they are succeeding than because they have failed in their business plan. Even slight slipups can be used in certain circumstances as an excuse for remodeling a firm's interior while leaving its facade and foundation alone.

The biotechnology companies have been hiring talented young scientists at a furious pace for the past few years. Many of these scientists have been driven from universities where they had expected to settle and lead quiet lives doing creative research. That's gotten to be increasingly difficult because, as one such scientist recently remarked, "Not only can you not eat prestige, you can't do research with it either." Thus many young scientists have allied themselves in unlikely ways with these "wildcat cloning" companies.

Research requires money and talent. Directed research requires a certain knack, and it will take time to acquire that knack and to accomplish useful things with it. The main motivating factor that investors have dangled in front of these scientists upon whom they depend is money—the chief motivator they indulge themselves with. But the sophisticated investors who've bought into the biotechnology casino know full well that another factor must be deployed with all the skills of a consummate poker player who is poised either to bluff, stand pat, or call into play whatever other strategies a particular deal may dictate.

Patience. □

Slump hits gas-based petrochemicals

Producers of ammonia, urea, methanol, and formaldehyde now hope to merely match last year's production and avoid losing money

Bruce F. Greek
C&EN, Houston

The leading small-molecule petrochemicals made from natural gas got away with surprisingly good business through 1980 and part of 1981 while recession hit most of the U.S. chemical industry. Now they are slumping too. And their outlook for the next five years appears to have worsened radically.

Blame recession with anemic fertilizer, housing, and fuel markets. Blame steadily rising costs of U.S. natural gas. Blame a little overinvesting by producers. And blame a rising tide of imports.

For 1982, U.S. producers of ammonia, urea, methanol, and formaldehyde now hope just to match 1981 production. Beyond that, their hopes are few. This year might be the last one in some cases for maintaining even the current production level.

Producers are holding their breath on profitability and hope they don't lose money on 1982 production when all the costs are in. Two breaks might help a bit—declines in inventory and interest costs.

However, the profitability problem will continue because of steadily rising gas costs, soft product prices, and rising imports. Ammonia and methanol in particular will be coming to the U.S. from abroad produced with much lower-cost gas.

In 1982, if production does match 1981, producers could have a gross income of $5.5 billion at most. This might be up 5% over that of 1981. But the gain is only about half of the overall real inflation rate.

Selling prices of these chemicals haven't increased much during the past year. Prospects are slim for any increase this year and later unless producers find ways to pass on the cost increases in gas. The result will be similar to what is occurring in other parts of the chemical industry—capacity declines and rising imports.

Even now, for example, considerable ammonia capacity remains shut down. This situation is a concern in the fertilizer industry in that supplies should be increasing now as the main market season begins on farms. But with ammonia imports priced as low as any produced domestically, the incentive to restart shutdown U.S. capacity is low. If the capacity was shut down some time ago when natural gas prices were lower, restarting at new, much higher gas prices is very unlikely.

Key Chemicals

Imports of ammonia could rise partly because producing countries' own plans to use their ammonia can't be met for lack of economic infrastructure. Such a condition can further reduce prices, since some foreign producers might consider a little income better than none from plants running with low-cost gas.

Methanol has a junior version of ammonia's problems. Although little, if any, methanol capacity currently is shut down, plants now operate at low levels. Prices are weak, probably no better than a year ago, further mirroring the profit squeeze. Little improvement in operating rate will occur this year.

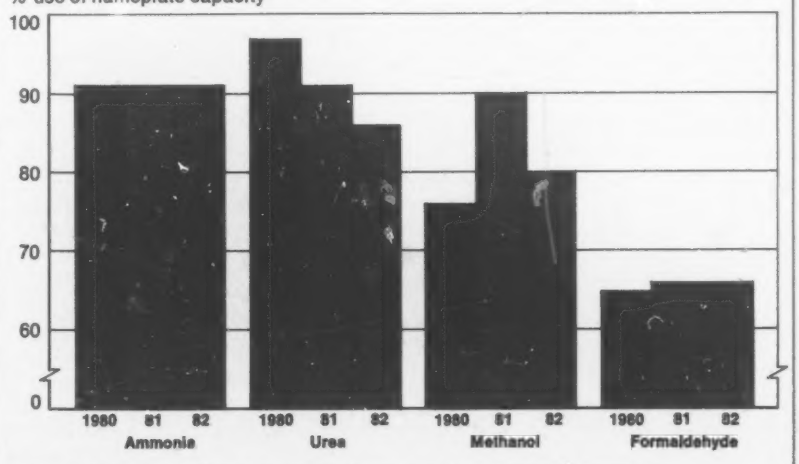
Methanol also is threatened with increasing imports from countries such as Canada, where natural gas is cheaper than gas in the U.S. The import wave might swell as decontrol of natural gas prices by whatever schedule raises U.S. gas costs.

Again, some capacity might be shut down, especially the older, less efficient plants. Retrofitting these older plants with energy-saving devices could help economics somewhat. But if the cost of imported material becomes notably lower than that produced in the U.S., even some of the more efficient plants will be shut down.

These relatively low-cost imports, now and in the future, could delay changes in natural gas-based petrochemicals' feedstocks to synthesis gas from other sources such as coal or heavy petroleum fractions in making ammonia and methanol. U.S. production from different feedstocks might not develop for a long time.

For details on the clouded immediate outlook for the major gas-based petrochemicals, see the following pages.

Some formerly high plant use rates will drop this year



Sources: Industry, C&EN estimates; Department of Commerce; International Trade Commission

Key Chemicals

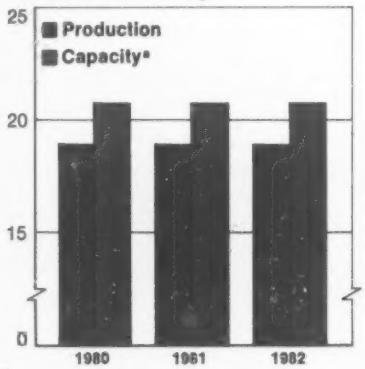
NH_3

Ammonia

- ***Demand tepid***
- ***Some capacity shut***
- ***Profits squeezed***

PRODUCTION/CAPACITY

Millions of tons as NH_3



[a] First quarter; includes capacity currently idled but not scrapped.

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen from natural gas

MAJOR DERIVATIVES (U.S.)

Nitric acid 20%, urea 20%, ammonium phosphates 15%

MAJOR END USES (U.S.)

Fertilizer 80%, plastics and fibers 10%, explosives 5%

FOREIGN TRADE

Exports—may reach 750,000 tons in 1982, imports—to hold at about 2 million tons in 1982

PRICES

$145 to $170 per ton at Gulf Coast plants

COMMERCIAL VALUE

$3 billion for production, 1982

Ammonia, as its chemistry suggests, frequently is a maverick among petrochemicals, straying from the herd in one way or another. Using the hydrogen rather than the carbon in natural gas, the acrid compound was true to form in 1981. It avoided the demand slump in most other fertilizer-related chemicals.

But ammonia may be roped into the general recession this year. It has not started out well. Producers are beginning to get their usual seasonal upturn for the spring planting season, but hopes are not running especially high. About the only big break ammonia has going for it is a holdup on the potential import flood that always threatens this market.

Meanwhile, U.S. ammonia producers have to deal with the same background problems this year as in 1981—shutdown plants, rising costs of all-important raw material natural gas, weak farm income, and uncertain exports of derivatives. These factors alone, even without the recession, combine to keep a squeeze on profitability. Little relief lies ahead.

Companies' reaction is no surprise—a firm clamp on any new construction and shutdown or low operation of many present plants. Currently, nearly 1.5 million tons of annual ammonia capacity is shut down out of the total 20.8 million tons. Much of the rest has run during the winter at low rates between 50 and 80% of nameplate capacity.

The reason definitely has not been interruptions of natural gas supplies to ammonia plants. Despite ever-rising prices, gas limitations have been practically nonexistent. Rather, low levels of operation have been due almost entirely to slow demand combined with comfortable inventories.

Some seasonal pickup in demand is occurring as expected. Although it is too early in the spring to tell how large, production also has increased. A supply crunch during the planting season could occur if the weather opens up uniformly and farmers decide to spend more money on fertilizer instead of on other items such as equipment. These are big "if's," however, and frequently lead to surprises.

If weather and farmers' purchasing favor nitrogen fertilizer this spring, ammonia producers will have to decide quickly whether to restart currently shutdown plants. To some in the industry, none of the shutdown capacity will be needed this year. These sources assume high projections of planting intentions and a net of ammonia imports over exports. One result could be a small drawdown of inventories of ammonia and derivatives.

But other sources report that, even now, some shutdown capacity might be restarting. In a few months, perhaps an extra 1 million tons of annual capacity will be operating nearly all-out. The total production rate then would be over 20 million tons per year.

How long such a high rate holds up will depend on producers' next decision—their estimate of demand in the early part of the next fertilizer year starting in June. Producers will remember that this past fall U.S. fertilizer use disappointed them. On top of that, exports of derivatives, particularly diammonium phosphate, declined unexpectedly fast. Such events could occur this year too. Many producers doubt that very much more fertilizer will be applied this fall than a year ago. Some producers expect improved exports of derivatives this fall, but they are fresh from the shock of late 1981 and may take a wary tack.

Another big question in ammonia's important foreign trade is imports. Although imports loom large from a spate of new plants around the world, all kinds of obstacles seem to have cropped up. For example, operating problems and growing internal demand might limit Mexico's ammonia exports to the U.S.

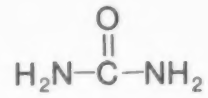
If derivatives exports increase this fall and ammonia imports don't break loose, current improved ammonia demand might hold up through the second half of 1982.

Nonfertilizer uses of ammonia are expected about the same this year as in 1981. Explosives uses are up a bit but are insignificant in total demand. Other chemical uses in downstream fibers and plastics products will do well to match 1981.

But these markets are all small compared to fertilizer. Unfortunately, they won't save ammonia producers from a lot of guesswork this year stemming from ammonia's quirky worldwide fertilizer market.

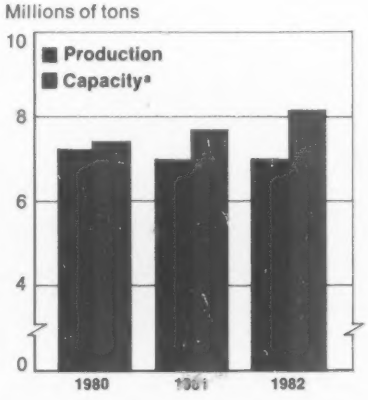
Key Chemicals

Urea



- ***U.S. demand off***
- ***Exports way down***
- ***Good times over***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 10%, melamine resins 5%

MAJOR END USES (U.S.)

Fertilizer 75%, adhesives and plastics 15%, animal feed 5%

FOREIGN TRADE

Exports—down sharply to as little as 1 million tons in 1982, imports—down to about 1 million tons

PRICES

$150 to $160 per ton on Gulf Coast

COMMERCIAL VALUE

$1.25 billion for production, 1982

The bloom suddenly has gone from the urea business, one of the brightest in the entire U.S. chemical industry until the fall of 1981. U.S. demand has eased, and formerly robust exports have fallen apart.

As yet, no resurgence is budding for 1982. Bad weather, of all things, might help urea this spring or early summer, but it is too early to tell.

After a long upward trend in production coupled with vigorous plant expansions, urea output tumbled in 1981—nearly 3% to 7.0 million tons, according to early estimates. Urea plants no longer ran all-out, and the scramble for raw material carbon dioxide subsided.

This winter, urea also suffered ammonia's malaise but on a smaller scale. Some capacity was shut down, and other operations ran well below optimum levels.

Some shutdown urea plants may be restarted by now, and others are scheduled to start up soon. As with ammonia, how long these plants will run and at what levels will depend heavily on weather, competition in fertilizer export markets, and inventories at various levels of distribution.

Not overweighting any of these variables, a producer consensus puts 1982 output at 7 million tons, about the same as in 1981. At this rate, nameplate plant capacity of about 8.1 million tons will run at an average of 86%. The range of estimated rates goes as low as 80% and as high as 90%.

This relatively wide range reflects the diversity of opinion on urea demand in fertilizer, its dominant outlet. The uncertainty is due largely to a surprisingly steep decline in exports in the second half of 1981 and slow export demand this winter. In 1980, exports jumped nearly a third to close to 2 million tons. Some small increase was anticipated in 1981 to push exports over 2 million tons. But to producers' dismay, exports fell because of an inventory pileup abroad in anticipation of the strong dollar and mistaken U.S. enthusiasm for worldwide demand growth. When all the figures are in, 1981 exports may total only 1.5 million to 1.6 million tons.

The wrenching shift in export demand, 300,000 to 400,000 tons, or 5% of nameplate capacity, clearly was felt in the market. Industrial uses of urea also suffered as a result of a slump in housing construction affecting urea outlets in adhesives for plywood and particle board. The total drop in 1981 demand might have been as large as 500,000 tons.

Since urea production did not fall 500,000 tons in 1981, inventories built up. A lot of that inventory overhangs the fertilizer market as urea-ammonia nitrate solutions. Carrying this inventory likely is getting burdensome, and fertilizer dealers probably are eager to move it.

But weather comes into play now. If the Midwest remains wet this spring, making field work more difficult, corn farmers might use less ammonia fertilizer in the preplanting stage. After the corn is up and strong, farmers might compensate with alternative "side dressings" of solution fertilizer to provide the required nitrogen. If this happens, the urea solution inventory would disappear and the urea business get a lift. But if the sun shines, ironically, urea might be in trouble all year unless exports somehow recover.

The nonfertilizer markets for urea are mostly in animal feed and industrial resins for various applications. The feed outlet is not expected to grow in 1982 because of competition for urea from soybeans as a nitrogen source. Soybeans might replace cotton to some extent in fields this year because of last year's bumper cotton crop and slumping cotton exports. Then soybean prices might be low and feed use might be up at the expense of urea.

The resin markets for urea are largely in making particle board and melamines. Particle board production has been falling as inventories built up with the decline in housing. Even if housing does pick up a bit in 1982, little help is due for urea because of the lag in adjusting inventories.

Melamines and the third largest resin use, plywood, have much the same outlook and a similar need for inventory pruning.

Surrounded by such markets, urea producers will need an unaccustomed patience in 1982. At least they did fairly well in 1980 and much of last year, when most of the chemical industry did not. This year they joined the crowd.

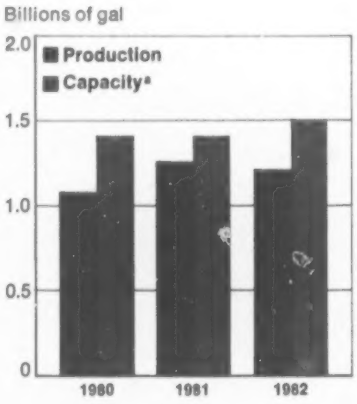
Key Chemicals

Methanol

CH_3OH

- ***Demand to ease***
- ***Capacity due way up***
- ***Prices discounted***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Reaction of carbon monoxide with hydrogen made by reforming natural gas or heavier hydrocarbon fractions

MAJOR DERIVATIVES (U.S.)

Formaldehyde 30%, acetic acid 10%

MAJOR END USES (U.S.)

Polymers used as adhesives, fibers, and plastics 50%; solvents 10%

FOREIGN TRADE

Exports—declining to 75 million to 100 million gal in 1982, imports—holding at 30 million to 40 million gal

PRICES

List 70 to 75 cents per gal at Gulf Coast plants; discounting large

COMMERCIAL VALUE

$750 million for production, 1982

U.S. methanol producers seemed to improve much of their business last year. For instance, they increased production almost 18%, according to early estimates, and they more than doubled exports. They also improved plants to gain efficiency and some capacity.

But producers are still worried. One big concern is what they couldn't do last year—evade a profits squeeze. Costs are mounting for natural gas, the primary fuel and feedstock for methanol. Yet real methanol selling prices fell because of discounting. So far, efforts to shore up prices in 1982 haven't succeeded.

Prospects for price recovery later on aren't very good, either. The basic reason is a big investment change coming for this business. After several years of steady plant capacity and generally high capacity use, methanol faces a big block of new capacity coming on stream this year in the U.S. and Canada. Compounding the resulting dismal pricing outlook are less than expected prospects for methanol in making the new gasoline octane booster, methyl *tert*-butyl ether (MTBE), and a sickly construction market for methanol's leading derivative, formaldehyde.

In 1981, methanol enjoyed average plant use of about 90% of nameplate capacity. A big help was exports of 126 million gal for the year, two and a half times 1980 exports. Total production rose to about 1.26 billion gal from 1.07 billion gal in 1980.

In 1982, production may ease a bit. The big problem is that exports may fall 20 to 30% as new Canadian plants are started up and beat out U.S. exports on price. If the MTBE outlet does modestly well, if derivative acetic acid demand keeps growing, and if formaldehyde doesn't sink too badly, then 1982 production might be off just a bit from 1981 at about 1.2 billion gal. Plant use would stay better than average in petrochemicals at 80% of nameplate capacity.

But 1982 might be the last year for such relatively high operating rates. Late this year and early next, methanol capacity will grow more than 20% if all units under construction or modification are completed and come on stream. By mid-1983, U.S. capacity could top 1.8 billion gal a year, up from the current 1.5 billion gal. Unless 1983 turns out to be a banner year for the major uses of methanol, plant operating rates surely will decline, putting more pressure on methanol's profitability.

Other than exports, most methanol markets proved disappointing in 1981 and have done little better so far in 1982. Formaldehyde continues to face heavy downward pressure on its main end uses in resins. As a result, the share of methanol production going to formaldehyde is dropping sharply. Even the best formaldehyde growth forecasts lag well behind growth foreseen for methanol in fuels, acetic acid, and other chemicals.

Formaldehyde's difficulties stem from its dependence on housing and other construction. As a methanol outlet, formaldehyde may barely hold even in 1982 or, more realistically, decline. This decline, together with the export dip, leads industry analysts to predict the small decline in methanol production in 1982.

Among chemical uses of methanol, acetic acid continues to be a bright star. New plants have appeared making acetic acid from methanol through reaction with carbon monoxide. More are coming. This year acetic acid is forecast to take 125 million gal of methanol, most of it produced captively (in-house).

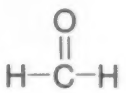
The other potentially bright star for methanol, MTBE, hasn't yet turned out to be the supernova expected by some in the industry. This year MTBE could take as much as 100 million gal of methanol, although it may not. The problem for MTBE is declining U.S. gasoline demand.

Lower gasoline demand means that there are plenty of competing gasoline blending components available, including aromatics such as toluene and mixed xylenes. Prices for these aromatics, just as useful as MTBE in octane boosting, are also competitive. So, if refiners have some unused aromatics capacity, they likely won't buy MTBE from the outside.

Other fuel uses for methanol are farther away, if possible at all, even though some developers' enthusiasm runs high. Experimental work on methanol in motor fuels will grow. However, it won't mean much to methanol producers this year. They will have to struggle to find markets for their excess capacity.

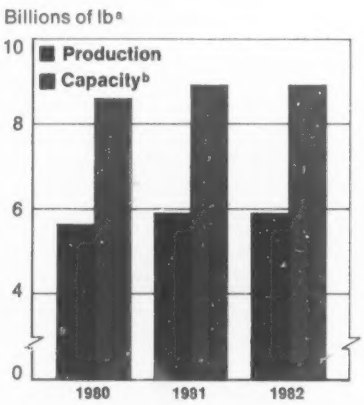
Key Chemicals

Formaldehyde



- ***Demand weak***
- ***Plant use low***
- ***Prices discounted***

PRODUCTION/CAPACITY



a As a 37% solution. b First quarter.

HOW MADE

Catalytic oxidation of methanol

MAJOR DERIVATIVES

Urea-formaldehyde resins 30%, phenol-formaldehyde resins 20%, polyacetal resins 5%, butanediol 5%, pentaerythritol 5%

MAJOR END USES

Adhesives 60%, plastics 15%

FOREIGN TRADE

Exports—small, under 20 million lb in 1982, imports—negligible

PRICES

List about 9 cents per lb for 37% solution; discounting large; merchant volume small

COMMERCIAL VALUE

$500 million for production, 1982

Formaldehyde never had the most upbeat public image, associated as it is with funeral homes and storeroom bottles in biology class. But as a business, formaldehyde built up over the years to rank 25th among all commercial chemicals in C&EN's Top 50 listing, ranked in terms of volume produced. It found cheap mass markets, most importantly as an effective resin binder material in plywood and particle board in housing.

However, formaldehyde's public image may start to give it problems, just when the chemical can least afford it. Its business side is already in deep trouble this year because of the slump in housing. Now the product has a new setback owing to toxicity: The Consumer Product Safety Commission this quarter banned further installation of urea-formaldehyde foam insulation (see page 34).

The ban has little impact on sales of this insulation, which already have plummeted, but it adds to unfavorable opinion toward formaldehyde. That could mean lower demand sooner or later for this most important derivative of methanol.

Early estimates for 1981 formaldehyde production, at 5.9 billion lb considered too high in some quarters, would mean about 5% growth over 1980. This occurred even though most producers of urea-formaldehyde insulation quit the business. Insulation sales fell nearly to zero after early publicity on toxicity of the resin's formaldehyde.

For 1982, industry analysts believe that just matching 1981 would be a success. Even so, considerable improvement would be necessary in the economy, and the second half must bring significantly stronger demand. In other words, housing and other construction must snap back soon so that inventory of plywood and particle board starts to move into the market. Then building materials production could resurge, followed closely by an upturn in resins.

If demand for these wood products doesn't pick up smartly, then all bets are off on 1982 formaldehyde production. Continued stagnation in construction could mean as much as a 10% decline in formaldehyde production in 1982 to 5.3 billion to 5.4 billion lb (as 37% solution in water).

Operating rates for formaldehyde plants have been quite low for some time. In 1981, plant use was not over two thirds of nameplate capacity, probably a bit less. In 1982, if demand slumps, operating rates might get close to 60% of capacity.

Some capacity likely will be shut down for long periods in 1982, leading to questions on what the total operable capacity really is. A relatively large number of formaldehyde plants are small and old, with capacities less than 100 million lb a year. Often these small plants were built to supply resin material to nearby wood products plants owned either by the formaldehyde producer or by close customers.

When demand for the wood products falls, economics might weigh against continued operation of these satellite formaldehyde plants, especially if supplemental merchant sales are unavailable for the plants. Merchant sales may be difficult, since formaldehyde is seldom shipped very far.

The upshot is that some local plants now shut down may never be restarted. Economics may favor outside purchase of resins for producers of plywood and particle board.

So during 1982, expected capacity expansions of 200 million lb or so (37% solution equivalent) easily might be offset by shutdowns. The amount of capacity closed permanently could be even larger, but it will take time for the shakeout to come clear. Current total capacity is 8.9 billion lb per year.

The toxicity issue, a big potential lever for this shakeout, so far has significantly affected only a small part of formaldehyde use. Coming workplace toxicity problems, if any, haven't yet cut into formaldehyde volume to any great extent.

Smaller uses of formaldehyde generally involve a change in molecular form and so obviate downstream toxicity problems from formaldehyde per se. But these uses still are affected by changing market demand. Individually, such uses can make little difference in total demand for formaldehyde. Their growth rates, with two exceptions, are about the same as for formaldehyde itself. The exceptions with faster growth are polyacetals and acetylenic chemicals, of which butanediol is the largest.

Progress slows in chemicals from synthetic feeds

Although pushed strongly by their backers, synthesis gas-based chemicals derived from coal and other unconventional raw materials are having a hard time lately. Not only has government sponsorship lightened up, but economic analyses in private industry have become more conservative in forecasting syngas process development.

One of the most conservative new forecasts says flatly that the unconventional chemical raw materials will get little use until the turn of the century and maybe not even then, depending on cost and supply of crude oil and natural gas. Economics of synthesis gas (hydrogen and carbon monoxide) or liquid hydrocarbons made from coal, oil shale, or tar sands likely will remain unattractive for some time unless government subsidies prop up their economics.

To judge synthesis gas for wide use beyond present processes making methanol and ammonia, several economic factors must be considered, says William A. Brophy, process technologist at Chem Systems. One critical factor is the size of the synthesis gas plant. Another is the type of financing secured for a project. But probably the most important factor of all is the price of crude oil.

Current economic analyses indicate that a synthesis gas plant will need a capacity of about 200 million standard cubic feet per day to gain the necessary economies of scale. However, above this capacity level, economies don't improve much further, Brophy told a Chemical Marketing Research Association meeting in San Antonio, Tex., earlier this month.

The financing assumed by Brophy in his economic analyses includes a 70-30 debt-to-equity ratio, 20% simple return on equity, and a 20-year debt repayment schedule at a 15%-per-year interest rate. Straight line depreciation over the 20-year life is assumed. The site would be at a mine mouth in the Midwest. Coal is assumed to cost $1.85 per million Btu in 1985 and $2.78 per million Btu in 1990.

Total costs of the synthesis gas, at a 0.6-to-1 hydrogen-to-carbon monoxide ratio in 1985, would run about $3.50 per 1000 standard cubic feet. Costs would rise to about $5.50 by 1990. If this ratio were 2 to 1, costs would increase 30 cents per 1000 scf in 1985 and 55 cents in 1990. A 1-to-1 ratio would result in about half of these additional cost increments, Brophy says.

More favorable financing might lower synthesis gas costs and in fact might be necessary to provide sufficient incentive to make new chemicals based on synthesis gas. Accelerated depreciation, lower interest rates, and a lower return on equity could help but probably would not bring the effective cost below cash costs plus debt repayment, Brophy estimates.

Critical to new production economics for chemicals from synthesis gas is the price of crude oil. In general, 1990 prices of crude oil would have to be about $100 per barrel (compared to a weakening $30 at the moment) for the economics to be marginally attractive. If crude oil were $70 per bbl, Brophy says that none of the synthesis gas chemicals would be produced competitively.

For example, Brophy estimates that ethylene via naphtha or gas oil cracking in a plant with a 1 billion lb-per-year capacity would have a projected product price of 61 cents per lb in 1990 if crude oil cost $70 per bbl. (Ethylene currently lists at 25.5 cents per lb.) At the same time, ethylene made by methanol cracking would cost $1.21 per lb; by methanol homologation, 92 cents per lb; and by a modified Fischer-Tropsch process, $1.16 per lb. Credit is taken for coproduct propylene at 53 cents per lb in each route. Synthesis gas would cost $5.70 per 1000 scf for a 2-to-1 hydrogen-to-carbon monoxide ratio or $5.40 for a 1-to-1 ratio.

These costs could come down if return on equity were reduced and/or if synthesis gas costs came down to $4.00 to $4.15 per 1000 scf. They might be as low as 52 cents per lb of ethylene by naphtha or gas oil cracking, 84 cents by methanol cracking, 70 cents by methanol homologation, and 89 cents by modified Fischer-Tropsch.

These products would be a bit more competitive if crude oil cost $100 per bbl. The projected price of ethylene from naphtha or gas oil would rise to 73 cents per lb.

In other areas of unconventional feedstocks for chemicals and fuels, the outlook also is for attainment of just a tiny share of the total feedstock supply. By the year 2000, Charles R. Greene, manager of synthetic fuels at SRI International's energy center, estimates, coal liquids produced by hydrogenation might reach 125,000 bbl per day. Output might be 20,000 bbl a day by 1990.

Liquids from both oil shale and tar sands will be less than 500,000 bbl per day by 2000, well under 5% of the estimated liquid petroleum demand of 14 million bbl per day. Greene's 1990 estimate is less than 150,000 bbl per day of these liquids.

However, he emphasizes that these small production rates are still important. They would demonstrate commercial development of the technology and open a route to more energy independence for the U.S. in the event of another crude oil supply interruption. □

Potential large-scale syngas-based processes would produce both fuels and chemicals

Chemical	Process	Typical capacity	Raw material	Syngas required (millions of scf/day)
Ethylene	CH_3OH homologation	10 billion lb/year	CH_3OH-syngas	305
	CH_3OH cracking	10 billion lb/year	CH_3OH	520
	Fischer-Tropsch	10 billion lb/year	Syngas	850
Liquefied petroleum gas	Fischer-Tropsch	425 million gal/year	Syngas	975
Ethanol	CH_3OH homologation	120 million gal/year	CH_3OH-syngas	22
Ethylene glycol	Union Carbide	500 million lb/year	Syngas	74
	Chevron	500 million lb/year	CH_3OH-syngas	62
Gasoline (aromatics)	Mobil	5000 bbl/day	CH_3OH	120
Acetic anhydride	Halcon/Eastman	500 million lb/year	CH_3OH/CO	49
Vinyl acetate	Halcon	350 million lb/year	$CH_3OH/CO/H_2$	60

a 70/30 ethylene/propylene. **Source:** Chem Systems